98/SF/61/Dabwali

Final Report

Report on Biomass Assessment Study in Dabwali block of Sirsa district (Haryana)

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1

Introduction

In India the demand for electric power is increasing at compounded rate of over nine percent which is one of the highest in the world. The installed capacity has increased to over 84000 MW in 1996, which is 49-fold more than the installed capacity in 1951 (TEDDY, 1997/98). Still the peak load management remains the major problem. Thus increasing power production is inevitable and power production based on coal, lignite, oil, natural gas and nuclear sources are being geared. Still hydel power remains the most preferred route and efforts are being concentrated to increase the share of hydel power, which is characterised by long gestation period in construction and number of environmental considerations. Thus, power production based on locally available resources make an attractive option and biomass offers a great potential, which needs to be explored.

India is a populous country, which houses almost one fifth of world's human population. Majority of the population lives in rural areas and chiefly depends on biomass resources for meeting energy demands. Therefore, most of the land has been put to biomass production of one or the other type. Besides the land based biomass production, a number of agro-industrial processes also generate biomass, which are consumed for energy end-uses. The biomass are also being used for various other purposes. Hence, estimation of the surplus biomass and real availability for power production becomes critical.

The rural energy needs a focused planning, especially because of little number of options available in rural areas. The energy planning in rural areas may be a synonym for biomass planning and in most of the cases gets linked to overall development planning. Biomass is generally being consumed in traditional and often, less efficient ways. Promotion of various fuel-saving technologies like Improved *chulha*, biogas plants, water heating devices have demonstrated conservation and efficient use of different bio-fuels. Now the efforts are progressing to utilise biomass resources, in an efficient way, for power generation like sugar-cane bagasse based co-generation in sugar industry and gasification of rice-husk. The options are quiet new to India but have established their utility under experiment phase as well as in field, in some other countries. However, the technologies are suitable for pilot level installations in India.

conception of field realities while planning at a macro level and implementing it with target firing approach. In last two decades, complexity of rural energy planning have been seriously considered and linked with overall development planning by way of decentralised planning. To make decentralised planning more flexible, relevant and integrated with planning at higher levels, it is being done at block level i.e., Integrated Rural Energy Programme (IREP) which was coordinated by Energy cell of the Planning Commission. The Ministry of Non-conventional Energy Sources (MNES) earlier started with village level planning and implementation of projects under the *Urjagram* and Reference *Urjagram* programme. Later it attempted to develop methodology for district level energy planning in selected districts of the country. In order to be close to the level of implementation as well as administration, MNES has now chosen to make energy plan at block level. The block level biomass assessment studies are being commissioned in a phased manner. About 100 studies were financed last year and about 60 have been funded this year, through out the country.

The scheme of developing block level planning aimed at more than 1MW power generation by using local biomass. Since the blocks have different area coverage by grid; levels of electrification; status of power supply and the power consumption pattern, the blocks may have particular development priorities for power generation as well as it's consumption. The planning process has to deals with the supply of required fuel for power generation and the technology. The nature of supply, in terms of location and quantum, defines the size of power generation and hence the scope of proposed application. A large power generation unit may give a feed to grid whereas a decentralised unit may energise some small community level application. Moreover, isolated power generation may create a replicable demonstration of independent decentralised energy unit in the blocks, which are not connected to grid.

Biomass or energy planning at any level would need a suitable database and the need is more desperate at a micro-level. Most of the surveys gather very good information on biomass consumption side. However, due to various technical issues related to the availability of suitable data and to the technical nature of the resources, the biomass supply is not assessed in detail. Supply side computations are generally based on broad-based assumptions on land-use and regional level biomass productivities, wet to dry ratios, collection efficiencies, harvesting as well as collection practices, etc. However, for a micro-level planning the factors should be researched at local level and included in the computations.

nature of study is primarily secondary data oriented and all relevant technical, financial and infrastructure related data was obtained from various Govt. Departments and Officers. However, a detailed questionnaire based primary survey was also conducted to assess local development priorities and feasibility of power generation. A cross section of society was interviewed and different industries were surveyed as per the MNES guidelines. The primary survey also crosschecked the facts revealed from secondary sources. Hence major information were obtained and not scientifically developed.

The chapter on study area details demographic, geographic and meteorological information about the area. Majority of information was collected from block office and some were procured at district headquarters. The methodology section deals with the data sources, general approach to the estimations and formulae used for computations. However, specific methodology for some of the computations has been given in the relevant sections.

The chapter on biomass assessment depicts the maximum potential availability of different biomass in the selected blocks. The availability has to be discounted for various enduses and local un-recorded consumption. Actual rice-husk availability in the area as well as with individual mills was also computed and has been given in the section on Power generation scenarios. Besides that, the section also deals with the potential of power generation with different types of biomass resources and the associated pre-requisites. The conclusions on power production were drawn keeping in view the continuity of the biomass supply.

2

Methodology

Being a study in leading cotton-producing district of the state, it was primarily designed to focus on cotton sticks (crop residue) production. However, the biomass availability in the form of cow-dung, other crop-residues, by-products from Agro-industries and fuelwood were also assessed for the power generation in the study area. The study was based on secondary information and its analysis. However detailed primary survey was also conducted to verify the biomass scenario projected through secondary sources. Special emphasis was given to study the biomass disposal patterns, transportation arrangements, associated informal markets and other economical issues.

Table - 1. Data sources used during the study

S.No.	Information	Source
At District Headquarter (Secondary Sources)		
1.	District and block level landuse, Census records	Distt. Statistics Officer
2.	Kerosene, LPG supply	Distt. Supplies officer
3.	Industrial profile	Distt. Industry Officer
4.	District & Block profile	D.C. office, Block office and NIC
At Block level		
5.	Landuse, Census, industrial profile, trends in urbanisation and industrialisation, Organised and Un-organised industries, agriculture markets	Local Block Development Office & Industry Officer
6.	Growing stock, sustainable yield of forests	Divisional Forest Officer, Forest Survey of India reports
7.	Crop-wise landuse, grain productivity, grain to straw ratio, Irrigation systems.	Block Agriculture Officer, Secondary sources, Agriculture University
At Educational institutes		
8.	Crop-wise grain productivities, Land productivities status, biomass related ratios	Hissar & Kaul campus of Agriculture University
At Village Level (Primary Survey)		
9.	Livestock, Grain productivity, Energy & biomass consumption, biomass related ratios, Electrification, Agriculture development, market prices, transport arrangements, etc.	Villagers
10	Power requirement & consuption pattern, biomass processed or consumed, production process, electricity bills, details of generators, diesel consumption, power cuts, operational periods, etc.	Industries (Saw-mills, rice-mills paper board, etc.)

Secondary data was sought from District headquarter, office of the Block Development Officer, Industries Officer, District Planning officer, District Statistics Officer, Divisional Forest Officer, DIC office, Agriculture University and *Krishi Vigyan Kendera*. Latest data was obtained from local NIC office. Primary survey included detailed discussions with Govt. Officials, elected memeber to Panchayats, Village Pradhan and villagers in all the villages in the block.

Selection of villages

A clear instruction was given by MNES in the first review meeting of the biomass assessment studies held at Baroda on September 24, 1998 that either 100 villages or all the villages, which ever is less, should be surveyed. Therefore all the 49 inhabited villages in the block were surveyed. However, TERI had also studied various land-based parameters, prior to the orders, to select the sample villages and had presented the results to HREDA.

While selecting villages on the basis of various land based parameters i.e., Forest land, irrigated agri. land, Irrigated land as percentage of total land, and total village area, the cluster analysis was done by using computers. It was interesting to note that even if the computer was given an option of classifying all the villages in seven clusters, most of the villages were clubbed in one cluster. Therefore, it could be concluded that villages in the block were generally similar and smaller sample would also have produced the similar quality output.

Cattle Dung

People mostly have stall-fed livestock and cattle are grazed hardly for a fortnight almost all the dung produced was available for use. All the cow-dung from cattle-sheds was collected and thus the collection efficiency was 100 per cent. Buffaloes, generally of very good breed, were highest in number among the cattle. Dung is used for various purposes in domestic sector. The end uses and the quantities consumed for various end uses were also observed.

Formula used

Annual Dung Production = [{Avg. dung productivity x Total no. of cattle x Stallfed days x collection efficiency} + {Avg. dung productivity x Total no. of cattle x grazing days x collection efficiency}] x Wet to dry weight ratio

Agricultural crop residues

The area is primarily dependent on agriculture and follows the Cotton/rice-wheat rotation. Mustard is also grown on significant area. Most of the lands have more than 200 per cent cropping intensity. Consumption pattern of the resource and the land being diverted to some other crop were also studied. Crop residue production is the sum of crop residues from all the major crops.

Formula used

Cotton sticks production = Area under cotton in *Kharif* x cotton productivity x lint to stick ratio

Same formula is applied to estimate other crop residues also but cotton is the dominant crop so the formula is given for cotton only.

Productivity of grains in various crops and their residues was considered a major loose end in the biomass assessment studies conducted earlier. The information was gathered from number of sources like crop-specific Agriculture scientists, published literature, Dept. of Agriculture, Revenue Dept. (local *Patwari*) and villagers. All the figures were presented to HREDA and after discussion it was decided to use the productivity figures provided by the Dept. of Agriculture for estimating the crop residue production.

While conducting the primary survey and discussing the issues with villagers the land being diverted either to some other crop or Agroforestry was estimated. In Sirsa area cotton crop is being replaced by paddy. The related observations are detailed in the chapter on results.

Tree canopies

None of the village has area under forests. Hence, the source can not yield any biomass for power generation. All wood yield in the villages comes from private lands or roadside plantations. No estimates were made for the resource.

Productivity estimates made by Forest Survey of India (FSI) for the area were used (FSI, 1997). Hardly one Sq. km area has been classified as forests. The resource it self is meagre that can yield only negligible biomass for power production. Hence, the resource was also not estimated

Fuelwood market

In Haryana, certain tree species are exempted from restriction on felling, transport and trade. Therefore a significant amount of wood comes to informal wood market at Dabwali. A primary survey was conducted to quantify the wood coming to these markets and estimate the surplus wood, which may supplement the biomass supply for power generation.

Agro. Industrial products

Dabwali has only sawmills and a briquette producing industry. Therefore, sawdust and mustard briquettes are the only industrial products of interest. The industries were surveyed and the observations have been recorded in the relevant section.

Biomass and Energy consumption pattern

Consumption of various biomass in village, their alternatives, concerned costs and possible impacts on livelihoods were surveyed in the villages. Harvesting practices in agriculture crops, disposal of residues, labour availability, transportation arrangements, storage practices, market price, etc. were also studied. The information was required to assess villager's interest, real capacity and capability to supply the residues.

Real availability of the residues

Theoretically, the sustainable biomass production is the potential biomass supply for power production. For agriculture crops and tree crops, the annual production and the sustainable yield are potential biomass supply. But the real availability is affected by various factors of consumption, operationality, cost, and harvesting practices. In the study, the total biomass production for the resources is determined at first place and then a proportion of domestic consumption was subtracted from it to estimate the marketable share. The marketable share is the biomass, which can be marketed. It may either being marketed or can be marketed if suitable price is offered. The suitable price is governed by the existing demand for the biomass, market price, and cost of extraction as well as transportation of the produce in the days of increased workload due to harvesting and later, sowing operations. The suitable cost of many residues may render them un-economical for power production. Though the economics may turn favourable in future but currently, the really available biomass has to be identified. It was realised that the proportion of residues which is burnt in fields, harvested by Combine harvesters, or not fed to cattle can classified as the really available biomass. All the biomass which are available for power generation have to harvested, transported, stored and processed for producing power. During the process, depending on the nature of the biomass 10 – 20 per cent material may get lost. The loss is more in case of loose biomass like rice-husk, mustard dust, cotton chips in comparison to solid wood yield from forests and trees.

Procurement of biomass

Study of market related forces was specially emphasised. Therefore, the pre-requisites to biomass availability were explored in detail. The information like system for collection of biomass, features of informal biomass market, transport system, storage system, requirement of bailers, etc. were also researched. The information is detailed in a special section on availability of rice residues in the block.

Determination of Power production potential

For producing biomass-based power, combustion is the usual route. But recently gasification, co-generation and pyrolysis rotes have gained prominence mainly due to better electricity production efficiencies and less damage to environment. Through the gasification route, 1.2 kg biomass is required to produce 1kWh power (Paul and Mukunda, 1993). Direct combustion route consumes almost 24.9 % more wood than gasification route and may consume 1.5 kg wood to produce 1unit of power (D.L. Brink, et.al., 1977). The MNES and HREDA suggested to use the conversion factor of 1.5 ton per MW per hour. Thus,

Annual biomass requirement = Biomass consumption/hr * Working hr/day * days/yr = 1.5 * 24 * 350 = 12600 ton biomass

Formula used for estimating power potential

Power Potential (MW) = Real biomass availability (ton) / 12600

3

Study Area

The biomass availability for power generation was assessed in the Dabwali block of district Sirsa in Haryana. The district, in western part of the state, share border district Hissar (Haryana), Rajasthan and Punjab State. The block is primarily agriculture based and does not house industries. However, a few industries were started and later closed, on paper. Last year a small briquette industry has been set up to process mustard dust. In Sirsa district 78.8 per cent of total population lives in rural areas.

Table-2. General information on Study area

S.No.	Information	District Sirsa
1.	District H.Q.	Sirsa
4.	Selected block	Dabwali
5.	Block H.Q.	Dabwali
6.	Development blocks	Dabwali
7.	Total blocks	7
8.	Major towns	Ellanabad, Kalanwali, Mandi Dabwali, Sirsa,
9.	Railway Stn.	Sirsa, Baragudda, (total nine stations)
10.	National Highway	NH-10, SH-23
11.	Human population (1991)	903536
12.	Urban	191200
13.	Rural	712335

Sources: 1. Statistical Abstract: Dist. Sirsa, Economics & Statistical Dept., Haryana
2. Census Handbook: Dist. Sirsa, Director of Census, Haryana

Landuse

Mandi Dabwali is the major town in Dabwali block, which is known for it's grain market. Being close to Punjab and Rajasthan borders, the town attracts lot of agriculture produce from the states. The town falls on the juncture of NH-10 (Delhi-Sirsa road) and SH-2 (Patiala-Sri Ganga Nagar road). One crop-residue processing industry has come up in the block owing to the agriculture dominating background and land use. In Dabwali block, more than 91.9 % of geographical area is cultivated and 62.6% of the cultivated area is irrigated.

Table-3. Landuse in the selected block

S.No.	Information	Area (ha)
1.	Geographical area (ha)	82467.85
2.	Cultivated area (ha)	75792.15
3.	Irrigated area (ha)	47436.70
4.	Non-irrigated area (ha)	28355.45
5.	Culturable wastelands (ha)	332.48
6.	Village forest area (ha)	-
7.	Govt. owned forest area (ha)	-
7.	Constructed area (ha)	5665.22
8.	Number of villages	50
9.	No. of un-inhabitated villages	1
10.	No. of electrified village	49

Source: Census Handbook: Dist. Sirsa, Director of Census, Haryana

Demographic data

Sirsa district has four major towns namely Ellanabad, Kalanwali, Mandi Dabwali, Sirsa, which have their own Municipal Committees. As per census (1991) 21.6 per cent population reside in the urban areas. S.C. population constitutes almost 26.65% of the total population. The non-workers or casual labour are above 65.55 per cent of the total population i.e., one-third of the population is involved with regular employment.

Table-4. Demographic details of the selected block

S.No.	Information	In Dabwali block
1.	Human Population (Rural)	156549
2.	Human Population (Urban)	36197
3.	Decadal growth - Rural (%)	24.19
4.	Decadal growth - Urban (%)	24.51
5.	S.C. population	41571
6.	Literates in rural area (%)	38.54
7.	Literates in towns (%)	71.74
8.	Agriculture cultivators	19033
9.	Agriculture labourers	14341
11.	Main workers	48854
12.	Marginal workers	7979
13.	Non-workers	102013

Source: Census Handbook: Dist. Sirsa, Director of Census, Haryana

Meteorological data

The area falls in sub-tropical zone and experiences extremes of all weathers. It is very hot in summers and very cold in winter. Only rainfall data was available for the region. There are no special meteorological laboratories but the agriculture department monitors rainfall in Sirsa and Dabwali. The area gets an annual rainfall ranging between 150 to 500 mm, on an average, mostly concentrated in monsoon season.

Table-5. Meteorological data for the study area

S. No.	Parameter	Dist. Sirsa		
	Year	1989	1990	1991
1.	Annual Rainfall (mm)	435	169	461

Sources: Statistical Abstract: Dist. Sirsa, Economics & Statistical Dept., Haryana

Cropwise landuse pattern

The selected block is predominantly an agricultural block. Cultivation of crops like cotton, wheat, mustard and rice is the livelihood for majority of the families. Area under cotton is 37.4 percent of the total agriculture area sown in a year but among the *kharif* crops rice accounts for more than 90 percent cultivated area.

Table-6. Crop-wise land use in the selected block

Crop	Area (ha)	Per cent (%)
Cotton Desi	12600	10.3
Cotton American	33000	27.1
Wheat	30500	25.0
Pulses	22500	18.4
Mustard	23100	18.9

Sources: Dept. of Agriculture, Sirsa

Status of Irrigation

Government canals are the major source of irrigation in the selected block. However, it is a dry area and options for sources of irrigation are limited.

Table-7. Sources of Irrigation and area coverage

	Source	Area (ha)
1.	Tube well without electricity (TW)	264.0
2.	Tube well with electricity (TWE)	435.0
3.	Govt. Canal (GC)	46737.7

Source: Census Handbook: Dist. Sirsa, Director of Census, Haryana

Industry

Dabwali has only sawmills and a briquette producing industry. Therefore, sawdust and mustard briquettes are the only industrial products of interest. The industries were surveyed and the observations have been recorded in the relevant section. However, a list of major industries in Sirsa area is provided in Appendix-V.

ssessment

in the study include dung-cake, agricultural
d for energy purposes. The area being primarily
from land based and animal-based biomass
he area is used for irrigated agriculture and the
ductive. In the given socio-economic conditions
ve an important role and offer considerable
Thus all the sources were enumerated and the
ıs assessed. The present chapter has separate
t in the selected block and detail information on
ıe last, the biomass supply situations in Dabwali
eveal the comprehensive situation, in brief.

District Sirsa)

1.9 per cent of land under agriculture and has
s irrigation. People tend to cultivate most of the
of crop residues is high. The residues have a
er and fuel demands. No village in the block has
ıme time there is only a small area under Govt.
ass fuels is the livestock. People also consume
ıre fields, private lands and roadside plantations.
ıass from these resources was assessed and real
generation was estimated.

ɔn

breeds of cattle, mostly buffaloes. Some villagers
g to their financial compulsions. However, a few
ıgnificant number and dependence on the small
g more number of economically weaker families
ırger livestock per family. The average livestock
e block and in the villages with Marginal farmers
e most 5 cattle per family and the villages with
o more than 60% have more than 8 cattle per

Table-8. Livestock in the Dabwali block

S.No.	Livestock	Number
1.	Cow	33303
2.	Buffalo	45408
3.	Goat	21045
4.	Sheep	32654
5.	Donkey / Horse	194
6.	Pig	851

Sources: Statistical Abstract: Dist. Sirsa, Economics & Statistical Dept., Haryana

Note: Population of cows and bufaaloes was clubbed and used for estimating dung production.

Table-9. Information used for estimating cattle dung production in the area.

S.No.	Information	Value	Remarks
1.	Dung productivity	15 kg per day	Varies with a season, higher in monsoon
2.	Collection efficiency	100 %	Stall fed livestock
3.	Grazing days	15 per year	During rainy seasons
4.	Dry to Wet ratio	0.25	Dry weight is 25 % of the wet weight.
5.	Livestock population	78711	Domestic Cattle only.

Formula:

Annual Dung Production = {Avg. dung productivity x Total no. of cattle x Stall fed days x collection efficiency} x Wet to dry weight ratio

Calculations:

{78711 X 15 X 100/100 X 350} X 0.25 = 103308.2 tonne /yr.

Disposal of cow-dung

A quick decomposition rate of the organic material enriches soils and makes them fertile. So the cow-dung is mainly used as manure. Economically poor and land less people do not need organic manure and also do not wish to spend their little income on commercial fuels. Thus, the category uses crop-residues and cow-dung for fuel purposes. However, all the families use dung cake for heating milk on smearing heat. The dung is also used for plastering the floors and walls. The trend is decreasing due to cemented houses being constructed in the area.

Table-10. Disposal of cow dung

S.No.	End use	Percentage diverted (%)
1.	Fuel	20
2.	Manure	75
3.	Plastering	5

Theoretically the technology for power generation by biogas may exist but for installing a pilot level demonstration, the infrastructure required for collection, and distribution of dry biogas slurry has to be reviewed.

Fuelwood

None of the village has area under forests. Hence, the source can not yield any biomass for power generation. All wood yield in the villages comes from private lands or roadside plantations. No estimates were made for the resource.

Productivity estimates made by Forest Survey of India (FSI) for the area were used (FSI, 1997). Hardly one Sq. km area has been classified as forests. The resource it self is meagre that can yield only negligible biomass for power production. Hence, the resource was also not estimated

Saw dust

The urban areas of Dabwali have twenty five saw mills and produce about 5 Quintal saw dust daily. It was estimated by the following method that 2625 ton saw dust is produced annually.

Number of Saw mills in Dabwali - 25
Average saw dust production / day - 5 Quintals
The mills work round the year - 350 days
Annual saw dust production = 25 × 5 × 350 = 26250 Quintals = 2625 ton

Disposal of saw dust

Brick kilns are the major consumers of the sawdust. However, people in the urban areas also burn sawdust in traditional stoves. The dust is sold at a price of Rs. 0.50 / kg.

Mustard briquette

In Sirsa town five briquette industries were established to feed the fuel to brick kilns. Also, mustard has grown popular among industrialists as a fuel. Therefore, a market has come up for mustard briquettes. In Dabwali area, one person has established similar industry and supplies briquettes to the industries in Ludhiana, Amritsar, etc. in Punjab. The unit may produce 8-ton briquettes daily. If the plant runs for 360 days, the unit can produce 2880-ton biomass in a year. In coming year the unit may produce more and more number of such units may come up. The sector may be considered as a supplier for biomass for power generation. This may reduce problem of storage and bailing.

ture residues

griculture crops in the area are cotton, wheat, mustard and rice. ly people feed animals with crop residues. Nevertheless, the residues tton and mustard be used for fuel purposes. The residues from wheat, pulses, and barley are fed cattle. The residues from the field crops were ed.

-11. Crop-wise land use in Dabwali block

.	Crop	Area (ha)	S.No.	Crop	Area (ha)
	Cotton Desi	12600	4.	Mustard	23100
	Cotton American	33000	5.	Pulses	22500
	Wheat	30500			

: Dept. of Agriculture, Sirsa, 1997-98.

resting fact was regarding the productivities of various crops, which vith the source. MNES had expressed concern about use of authenticated roductivity values and ratios. Therefore the values and ratios were d from agriculture scientists, Dept. of Agriculture, *Patwari* and local After discussion with HREDA, it was decided to adopt the estimates y local Agriculture Department for computing the supply of agriculture s. There was not much difference among the grain to straw ratios d by various sources. Therefore, the ratios published by agriculture ts in research journals were used for computing the estimates.

-12. Area, grain productivity and production of agriculture crops

Crop	Grain Productivity (kg/ha)			
	Agri. Scientists*	Revenue Deptt	Agnculture Deptt.	Primary Survey
Rice Hybrid	5038	2959	3085	3000
Rice Basmati	4023	2959	3023	2800
Maize		1979	1896	2000
Suagrcane	6100	6100	6000	6000
Wheat	3685	3808	4053	4000
Sunflower	1863		1720	1500
Cotton	437	1705	1863	500
Mustard	1247	914	970	1200

* References given in the list of references

the crop residues, mustard dust and wheat straw have an already shed identity and marketed for fuel and fodder, respectively. For ion of the residues an informal collection system exists. The sticks of are normally given to labour as pert of their wages or burnt. Hence, the biomass may become available for power generation but an efficient collection mechanism has to be introduced.

Table-13. Crop residue production in the Dabwali block

Crop	Area (ha)	Crop prod. (Ton/ha)	Resi. ratio	Res. prod. (Ton)	Marketable (%)	Process loss	Production (Ton)
Wheat	30500	4.053	1.48	182952.4	80	2	109771.5
Mustard	23100	0.97	7.06	158193.4	100	1	142374.1
Cotton Desi	12600	0.347	13.93	60904.7	90	1	48723.8
Cotton American	33000	0.437	13.93	200884.5	90	1	160707.6
			Total	602935.116			461576.9

Sources: Area under crops and Crop production (Dept. of Agriculture, 1997-98)
Residue ratio (Agriculture /scientist, Haryana Agriculture University, Hissar & Kaul)
Marketable per Cent (Primary Survey) and Process loss (Assumption)

Mostly the farmers in the study area follow Cottton/rice-Wheat/mustard rotation. The cropping pattern may have an impact on total availability of biomass. Cotton is the major crop in the block and all the farmers grow it. But different crop-mix is adopted in various parts of the block. Areas close to Kalanwali town grow rice also in *kharif* season. Whereas villagers near Rajasthan border grow cotton only. In *rabi* season, farmers in the villages close to Kalanwali grow mainly wheat. Rarely, a few farmers grow mustard. Farmers close to Dabwali town have now started adopted rice in *kharif* and devote significant area to mustard in *rabi*. However, the villages near Rajasthan border mainly grow mustard in *rabi* season.

The residues are available at cheaper cost in their respective seasons and can be stored for significant time. Depending on the utility of the residues, precautions are taken and people have developed local mechanisms to store most of the residues. Since, the period for collection of the cheaper biomass is so short that an evolved and faster system has to be introduced in the area. Like a bailer system is essential for collecting paddy straw, a modified combine harvester which helps in gathering the straw also is required for wheat straw and a chipper and bailer system is required for pooling biomass from cotton sticks.

Disposal of agriculture residues

Wheat straw is very important for farmers for being a very good fodder. It is chipped and stored for sale as fodder or paper board factories. Domestic fodder consumption is 25.6 percent and about 54.8 per cent wheat straw is sold to industries, dairy, and individuals. Informal market also stores huge quantities However, the large farmers can easily spare large quantities of the biomass as almost 40 per cent residue is wasted during harvesting by combine harvesters

The resource goes as waste. Moreover, the economically well-placed farmers generally have small livestock and thus have smaller fodder requirement. Thus, a large quantity of the biomass goes waste and may be procured.

Cotton sticks were once procured by theinformal market for M/s NUCHEM Ltd., who produce power in Tohana town (Haryana) and used the residue for the cause for one year. Otherwise the residue is used as domestic fuel. Even after luxuriant consumption and distributing the biomass to needy and labour as wages, farmers consume only 25% of the resource. Almost 20 per cent crop is burnt in the field and about 54 per cent is ploughed back in soil.

Mustard dust (chipped mustard sticks) is used as industrial fuel and purchased by the traders at an attractive price. The demand for the resource remains more or less uniform through out the year, the residues is stored, transported and stored in a readius of 400 – 500 km. Mustard sticks are also used as fuel in rural domestic sector. Therefore, about 8 per cent resource is consumed in-house and remaining 92 per cent is sold to traders and industries.

Table-14. Summary of biomass consumption

Biomass	Cost (Rs/Qn)	End use	Waste?	WASte (%)	Season	High availabilty	Issues
Rice husk	80-150	Fuel	No			KKR	
Light rice husk	200-300	Feed	No			KKR	
Bran	300-425	Oil	No			KKR	
Bran (*Saila*)	800	Oil	No			KKR	
Rice straw	15-45	Fuel	Yes	50-60	Oct-Feb Jul-aug	KKR	Bailer needed, Ash disposa mechanism, collection syst
Wheat straw	80-180	Feed, Indu.	Yes	25-50	April-May	Sirsa	Modified combine harveste required
Mustard dust	15-50	Fuel	Yes	0-20	March-May	Sirsa	
Cotton Sticks	4-5	Fuel	Yes	20-80	Nov. -Dec.	Sirsa	Baoling/chipping is a proble when dry
Briquette	70-160	Fuel	No			Sirsa	

Note 1. KKR - Kurukshetra

2. Waste - Portion that really goes waste. Either burnt, ploughed back or harvested by combine.

It is re-emphasised that marketable portion of residues is the part which may come to market after granting the domestic consumption. However, the waste per cent is the amount, which goes waste in any case because the residue is either burnt, ploughed back or harvested by combine.

Overall biomass production scenario

The biomass may have a market and a price attached, as mention in the relevant sections, but the resources have been estimated to compute availability of biomass production for power generation based on the local biomass supply. Real availability (based on surplus) is depicted in a separate section on power production potential in the Dabwali block.

Table-15. Over biomass supply situation in Dabwali block

S. No.	Biomass	Production (Ton)
1.	Cow dung	103308.2
2.	Cotton sticks	261789.2
3.	Saw dust	2625
4.	Briquette	2800
5.	Wheat Straw	182952.4
6.	Mustard Dust	158193.4

Domestic fuel consumption

The domestic sector denotes an inhabited area inclusive of commercial installations like markets, roadside hotels, teashops, etc. in the rural areas. Fuel value, availability and market price generally guide the consumption of biomass for an energy enduse. In the study area major fuel used are cotton sticks, dund cakes, fuelwood, and kerosene oil. Slowly people are shifting to commercial fuels like, LPG, electric thermal gadgets and biogas plants.

Table-16. Domestic fuel consumption in the study area (% of Households)

S.No.	Fuel consumed	Block Dabwali
1.	Crop residues	95.0 ± 2.6
2.	Dung cake	2.3 ± 0.7
3.	Fuelwood	1.9 ± 0.8
4.	Kerosene oil	1.4 ± 0.6
5.	L.P.G.	1.7 ± 0.7
6.	Biogas	1 ± 0.3

All the families use various fuels and the consumption mix reveals the number of families preferring a particular fuel.

An effective extension program of biogas plants may receive proper response and help farmers produce organic manure for agriculture field while meeting domestic fuel needs. Since a lot of crop residues are being used in the area, a program on improved chulha or smokeless chulha may be adopted well.

5

Scenario of power generation

Haryana State gets 2347.20 MW power from hydel (1063MW), thermal (1255.50) and nuclear (28.10MW) sources. The state has a maximum demand for 1947 MW and thus, the state may apparently seems to be a power excess state. But the demand for power in agriculture and industrial sectors peaks very high and the peak is beyond management with the present level of power production. Another important factor is line losses, which has been estimated to be 31.47 per cent. With the level of line losses, even normal power demand can not be satisfied and thus the state is actually a power deficit state.

Domestic, agriculture and industrial sectors are major power consumers as the sectors consume 2304468, 377479 and 74382 units respectively. Lower consumption by industrial sector highlights a lower industrial development in the state and secondly it highlights that the industrial sector generates power for their consumption. Thus, it further strengthens thc logic for additional power generation in the state. Realising the fact, partially, the erstwhile State Electricity Board (HSEB) issued 45 permits for 25 MW power-generating units based on liquid fuels. One of the plants has started operations in Faridabad. Further, the Board has taken encouraging initiatives by issuing power sector reforms, new power policy and is actively considering revising price for renewable resources (or biomass) based power. Thus, the investors are strongly encouraged to produce biomass-based power in Haryana.

Power supply to concentrated industries, with in a radius of 15 km, near Sirsa town makes a fit application for major power production in the area. All the industries complained about poor quality power supply and run diesel generator sets during the power cuts. The industries have there own generator sets, ranging from 58.5 to 250 KVA, which run for six to eight hours daily. Moreover, all the industries reported a major problem due to poor power supply and power cuts for two to four hours daily for more than ten months.

Besides such a consumption scenario, prompting for power generation, the biomass supply side also reveals an attractive preposition for the cause. The section details the scenarios of power generation and associated prerequisite. Power and diesel consumption was assessed in different biomass producing industries to establish preliminary techno-economic feasibility of the power in the industries. Major power consumers industries in Sirsa area are detailed in Appendix - V.

Biomass resources in industrial sector

In Sirsa town five briquette industries were established to feed the fuel to brick kilns. Also, mustard has grown popular among industrialists as a fuel. Therefore, a market has come up for mustard briquettes. In Dabwali area, one person has established similar industry and supplies briquettes to the industries in Ludhiana, Amritsar, etc. in Punjab. The unit may produce 8-ton briquettes daily. If the plant runs for 360 days, the unit can produce 2880-ton biomass in a year. In coming year the unit may produce more and more number of such units may come up. The sector may be considered as a supplier for biomass for power generation. This may reduce problem of storage and bailing.

Power situation in biomass processing industries

The industrial profile of the study area reveals that there are no major industries in the area. Hence, all the power production intervention in industries banks upon the industries in Sirsa area. The Sirsa is almost 70 km from Dabwali town and the Dabwali blocks starts at about 40km from Sirsa. Most of the industries are cotton ginning mills and oil extracting units. Other industries are paperboard, rice-shrller and brick kilns. However, all the industries face power related problems and resort to their power generation through generators.

Table-17. Classification of the industries based on biomass use and probable application

	Biofuel consuming	Handle Biomass in process	Produce biomass output
Little heating requirement	Bakery, hotels, etc.		
Heating & Power requirement	Rice-mills	Rice-mills, Bran oil mills	Rice-mills, Bran oil mills,
Little power requirement		Furniture, ,Sawmill,	Sawmills
Major power requirement		Cold Storage	

Industries in the area normally run for 8 -10 months a year and invariable face a problem of power cuts for three hours twice in day through out the year. Besides, a low voltage supply is also a serious matter of concern. Therefore most of the industries maintain their own diesel run generator sets. Problem of power cuts forces the industries to have a back-up unit but a subsidy of Rs 1500 per KVA of the generator, from Industry Dept., encourages the people to install such generators. The subsidy amounts to almost 30 -50 percent of the cost of generator. The factor may act prohibitory to the use of renewable energy technology for industrial purposes.

Table-18. Power situation in various industries in the area

Industry	Operate (month/yr)	Size of Gen. Set (KVA)	Power bill (Lakh Rs)	Diesel bill (Lakh Rs)
Rice mill	8	140	2.5 - 4.5	2.0 - 2.5
Paper board	12	123	2.0 - 2.5	0.6 - 1.0
Oil mill	8	93	2.5 - 6.0	2.5 - 5.5
Cotton Ginning	10	140	3.5 - 6.0	2.5 - 4.5

It reveals that all the industries are paying huge sum of money for power and may like to adopt a dependable alternative. Thus, an application of major power production and supply to a cluster of industries may make an attractive option. The option of generating power for self-consumption and sustainability also makes sense. Especially M/s Jagdambey Paper Mill, which has a connected load of more than 2.5MW and their DG back up of more than 2.7MW, may go in for power production. Just adjoining to the M/s Jagdambey Mill, M/s Bhim Jhunthra Agrofuels manufacture mustard briquettes and the plant has a capacity of 20 ton per day. Based on the fuel power may be generated and a successful demonstration may be developed in the region.

Power generation scenarios in Dabwali block

In Dabwali block, no village forest or Govt forest exists. Govt. manages only roadside and canal side plantations, which may not yield any sustainable biomass for power generation. Major power is possible from agriculture residues. The cotton sticks and mustard dust are the most prominent biomass in the block, followed by wheat straw. It is possible to generate 24.5MW power in the block by using the locally available biomass and cotton sticks alone can generate 12.5MW. There are prerequisites attached to the availability of the resources like, collection system, collection efficiency, transport systems, and price.

Table-19. Power generation potential by using local biomass supply from Dabwali block

Biomass	Production Ton	Marketable (%)	Marketable biomass (Ton)	Process loss (%)	Available for power (Ton)	Power possible kWh	Power possible MW
Cow dung	103308.2						
Govt. Forest	0.832	100	0.832	10	0.7	499.2	0.0
Saw dust	2625	100	2625	20	2100.0	1400000.0	0.2
Briquette	2800	100	2800	10	2520.0	1680000.0	0.2
Wheat Straw	182952.4	40	73180.96	20	58544.8	39029845.3	4.5
Mustard Dust	158193.4	90	142374.06	20	113899.2	75932832.0	8.7
Cotton Sticks	261789.2	80	209431.36	20	167545.1	111696725.3	12.8
						Total	26.2

The largest single consumer for such a power production is the State Electricity Board. Specially if the power is produced in Dabwali area, where industrial consumers do not exist, the power has to sold to SEB (State Govt.). For the cause, all the concerned parties may have to enter a formal agreement, share capital investment, and negotiate tariffs and logistics for distribution of power and payments. The concerned parties are Haryana Renewable Energy Development Agency, Electricity Board, and private entrepreneur.

For collecting the cotton sticks generated in villages, the collection system has to be very efficient. There already exists an informal market system, which may be employed. Characteristics of the informal market have been dealt as a special box item, in the section on pre-requisites.

Prerequisite

Any entrepreneurer, venturing into power generation for more than 1 MW, would like to seek queries on the following:

1. Status of biomass supply
2. Status of technology, availability of repair and maintenance units
3. Economics of installation and operation
4. Status of electricity supply, chances of an up gradation of grid and nature of power cuts
5. Infrastructural, logistic and legal support from Government agencies.

Status of biomass supply for various resources is being reviewed and discussed in the report and status of technology and availability of repair / maintenance units vary with manufactures and should be asked in detailed. A list of addresses of some manufacturers is given in Appendix-IV. An economic feasibility for power generation by biomass and other conventional resources needs a separate detailed study. So, there are no comments on probable changes in economics of the power generation, its comparison with hydel power and grid expansion. However, relevant prerequisites have been highlighted while discussing the possible power generation. Factors like fluctuation in price, collection system, transportation arrangement, etc. also influence the availability of the biomass.

Changes in crop-wise land use

In last quarter of century the area under rice in Haryana State has increased by more than three times. Area under rice increased from 241000 ha in 1970 to 795000 ha in 1994-95 (CMIE, 1996). During the same time period the productivity has also increased from 1540 kg/ha to 2800 kg/ha. The increase may indicate an increasing source base and highlight an attractive biomass supply. While surveying different areas in Haryana, it was observed that area under agriculture is under going a change. Area under agroforestry is rising in both the blocks of Kurukshetra and cotton area is declining in Sirsa district. Cotton in Sirsa dist. is being replaced by rice.

Table-20. Changes in crop-wise land use in Haryana

Block	Crop Increasing	Crop Decreasing	Rate of Change in last year (%)	Expected change in next 5 year (%)
Thanesar	Agroforestry		10	30
Pehowa	Agroforestry		5	30
Baragudda	Rice	Cotton	5	50
Dabwali	Rice	Cotton	1	10

Interestingly, the changes in both the districts have started coming up in last three years. The area under Agroforestry may increase to 30 percent of the agriculture because these areas are not close to the Poplar market (i.e., Yamuna Nagar). Also, after four-five years poplar pices may fall due to excessive supply. Moreover, the wood being produced will go to Yamuna Nagar for processing and the biomass will be available there only.

The area under cotton has decline and may further decline due to very poor crop in last three years. In Baragudda, people were growing paddy and have further increased area under the crop by one to five per cent. The farmer may easily increase the paddy area to 50 per cent as the area has good ground water and gets sufficient chanal water for irrigation. Whereas in the Dabwali, the cotton area will decline at a slow pace and will not be replaced by paddy as the groundwater do not support good paddy crop. Therefore, the total availability of residues in Baragudda block may not significantly change in spite of change in crops. But the same may not be concluded for Dabwali block.

Variations in price of biomass

Villagers and the trader in residues felt that over last five years, there has not been a significant rise in the price. However, with in a season the prices vary drastically. Though there had been an increase in number of paperboard manufacturing units in Kurukshetra and briquette industries in Sirsa, but the opening price at factory compound has not varied more than a rupee or two. At farmer fields, people easily settle for almost the same low price every year because that saves them the labour of cleaning the fields. The price offered to farmers at their field is almost 30 to 40 % of the market prices. However, the rice-sheller owners get good deal for their by-products. Interestingly, the prices of various residues were almost similar in both the districts, probably because the traders operate across the region and thus, it is slightly an open market. Howevr, the price for residues is low during the harvesting season and later, it increases. The cotton sticks are not priced because there was a demand for the same only once when M/s NUCHEM Ltd. purchased it for two years. Otherwise there is no demand for the resource, except for domestic fuel and distributing it as wages to the agricultural labour.

Table-21. Market prices of various biomass products

Biomass	Marketable (%)	Use	Price (Rs/Qu)
Rice husk	5	Fuel	80 - 150
Light rice husk	100	Feed	250 - 300
Bran	100	Oil extraction	300 - 425
Bran (*Saila* var.)	100	Oil extraction	800
Paddy straw	90	Fuel	15 - 30
Wheat straw	80	Feed, Paper board	80 - 180
Mustard dust	90	Fuel	15 - 85

Mustard dust gaining popularity

Recently mustard dust has gained popularity due to very low ash content and relatively highly calorific value. The demand for the residue has increased in industrial sector and that too in the far off places. Mustard dust is being transported from Rajasthan to the cities like Ludhiana, Jalandhur and Amritsar to be sold as an industrial fuel.

Collection mechanisms for crop residues

Collection of the crop residues becomes an issue neither because it is a huge amount to be collected in a short span of economically viable cost, nor that farmer do not have time to transport it. But the collection becomes strategic because it is tactical to decide the price for the biomass, arrange for the manpower to harvest, tie as well as transport, and the employ a means for transportation of the biomass. Roughly, if daily 250 ton biomass may be needed for a 10MW power plant, the annual requirement will be around 91250 ton. All this biomass has to be collected within a fortnight of harvesting period (or at the most with in a month) from all the villages. A combine harvester would produce almost 4ton biomass in an hour. That means a harvester will generate 48 ton (or 50 ton in 12 working hours of a day) and will produce 1500 ton in a month. Imagine the number of combine harvester needed to just harvest the biomass. Then comes the infrastructure requirement for transporting the biomass from individual fields to store and then would be the need for proper storage mechanism. Since, the biomass would be loose and require long storage, so, bailers are required to process the biomass. Once it is bailed the biomass would need less space for storage and it is easy to transport. Therefore, mobile bailers would be required. May be a number of collection centers, stores or computerised weighing machines would be required.

Wheat is harvested by combine harvesters and the straw is wasted. Later, burned. If the harvester may be modified to collect the straw separately, the machine would very effective for collecting the biomass. Similarly the chippers used for cotton and mustard sticks may be improved. A special thrasher has been developed for chipping mustard. First all the pods or panicle portion of mustard plant is harvested to collect mustard seeds. Later the remaining plant is harvested and chipped by the thrasher. Chipped biomass is easy to handle and transport in comparison to sticks.

Cost of harvesting, labour requirement and cost of transport also affects the price of biomass. These days, in some areas, cotton sticks are considered problem in clearing fields. So it is donated, burnt or ploughed back. People would be happy to give it free of cost because it will clear their fields for next tillage and sowing. It may be true for most of rice straw also. But the scenario changes if farmers are expected to drop the biomass at power plant. These days combine harvester charge Rs 400 per acre for extracting grains and manual labour charges Rs around 1500 per acre (in cash or kind) for harvesting and transporting / loading. Normally the biomass productivity per acre ranges from 1.5 ton to 3 ton. Taking the average to be 2 ton, if a biomass is harvested mechanically it costs around Rs 0.10 per kg and with manual harvesting it costs about Rs 0.40 per kg. Adding the cost of transportation, cost for a day being wasted in transportation and farmers profit, the biomass may be tagged a suitable price. The paper board industries offer Rs 17 –20 per qn for paddy straw in the beginning of the season.

The Briquette industry

Taking an advantage of the popularity of mustard dust among industries, briquette industries have been established near Sirsa and Dabwali towns. The industries compress mustard straw (dust) to make 8 – 10inch long briquettes. The industries are capable of producing 10ton briquettes daily but produce something like 6-7 ton per day. The production may be doubled or tripled without any cash incentive, if a demand exists. The raw material i.e. mustard straw is available in plenty and increasing the production of the industries to five times is technically feasible. A power producer may considered the industries as a biomass collection mechanism and enter into a MoU with them. Under a MoU the industries may procure mustard briquettes required for running the biomass through out the year. Moreover, changes in crop-wise land use pattern do not threaten th production base of mustard in the region.

These are the pre-requisites if the power producer establishes own mechanism of biomass collection or encourages farmers to deal straight with the producer. But both the systems may have ifs and buts. There is another system of informal market existing in the area, which apparently looks much efficient.

The informal market for crop residues

A number of farmers and traders have adopted a role of middle man between farmers and industrialists for supplying them various crop residues used for fuel, packing material or feed. It is difficult to estimate either total number of traders or size of their business. But, it was evident that all industrialists and farmers knew about one or the other such traders. Another indicator of their huge business was their stock of mustard straw. The study was conducting in October and November, i.e., six month passed after mustard crop and it was supposedly the end for the mustard season as rice straw and cotton sticks start coming in November. It was observed that traders surveyed at that time had 12000 - 18000 ton mustard straw in their stocks. One can probably imagine the size of biomass they must have dealt in the season.

The traders in Kurukshetra area operate in a region of 300-400 km i.e., they gather various residues from as far as Jind, Hissar and Fatehabad and supply to industries in Delhi, Dehra Dun and Mujaffar Nagar. In Sirsa raea, their area of operation extends over 500 km. They procure biomass from number of districts in Rajasthan (the adjacent state) and supplies to the cities like Ludhiana, Jullandhur and Amritsar in Punjab. These people transport their material by trucks or tractors, which may carry 10 - 12 ton chipped biomass. The trolleys also have been modified to take 10 ton load. If it is rice straw or cotton sticks a trolley only transport 6-7 ton. Every trader owns alt least two vehicles and most of the traders are relatives so they often know about each other's stocks, movements and capacities. The traders deal in mustard straw, wheat straw, paddy straw, husk, and briquettes.

Table-22. Industries interested in different biomass

Biomass	Industries
Rice husk, Briquette, Mustard straw	Boiler based industries
Wheat straw	Paper board, Packing, Dairy
Rice straw	Paper board, Glass packing,

The traders felt that they may supply any amount of biomass if there are paid well in time because their procurement is a cash deal every time. Only risk factor is crop failure as in that case people loose interest in the crop and that leads to poor availability of residues.

Most of the prerequisites have been enlisted earlier. Still, a few, as expressed by industrialists are detailed below. However, most of these are technology related.

1. People are not familiar with the gasifier technology and have apprehensions. So in-depth extension and introduction to technology are required. All possible support may be extended during the demonstration phase.

2. Since the technology is new, entrepreneurs are hesitant in spending huge money for installation or capital investment. Also they would like minimum tampering with their generators, if those were used.

3. The technology should be as trouble free as the generator sets and maintenance or repair units should be readily available. Perhaps locals are trained on gasifiers. An entrepreneur may not like to lose because of technological failures.

4. The formalities involved in seeking permission for power generation may be reduced and an agreement with the Electricity Board may be simplified.

6 Conclusions

- In Dabwali block, processing crop residues through a gasification and combustion routes may generate major power. In the area, a huge amount of cattle dung is also available but may not be used for power generation.
- Total of 26.2MW power may be generated in the block using the local biomass. However, just through cotton sticks 12.8MW power may be generated. The units will run through out the year (350 days). The estimate is based on the marketable portion of the total rice straw produced in the block, assuming a process loss of 20 per cent.
- A power production in Dabwali is an attractive option because, for various reasons, farmers have limited options of crops. Therefore, the production base of major crops like Cotton and mustard will change only slightly, even in long run.
- Almost all the major industries are located close to Sirsa town. Thus, the power production in Sirsa makes better sense than producing power in Dabwali area. Power generation and distribution to the industries makes an attractive option.
- The local industrialists will appreciate a good quality power supply as low voltage supply and frequent power cuts are quiet erratic. Otherwise an option of producing power for the State is also an attractive proposal.
- Besides chipped cotton sticks, other prominent residues were wheat straw, mustard dust. Sawdust is also an important industrial fuel in the area.
- Power production option is possible mainly by using agriculture residues. All other biomass hardly makes a case for major power production. However, the resources may be used either for small-decentralised power production or to produce additional power.
- All the villages are electrified and the domestic sector mainly consumes cotton sticks and cow-dung cake for fuel. But, majorities of cotton sticks are wasted by either burning or ploughing them back. Moreover, generally crop

residues are sold and may be diverted for power generation by offering an attractive price.

- Theoretically, the biogas may be used for power generation. If a commercial level technology may be developed to use the resource, sufficient biomass may be available for the cause.
- The biomass is available at highly scattered sources and a well thought collection system should be installed in the area to pool the requisite biomass.
- An informal market exists in the area, which operates much beyond the study area and bring in the biomass. The market may be used to procure the requisite biomass, as one power producing industry is already producing power in Haryana State.
- Prices of biomass are more or less constant for last five years. However, within a year it varies drastically. Industrialists identify biomass availability at a regional level and the supply is still much larger than the consumption.
- People, industrialists and traders felt that arranging 300 ton daily, from the region, for power production is not a big deal. Thus, private entrepreneurs are encouraged to produce major power by using biomass resources.

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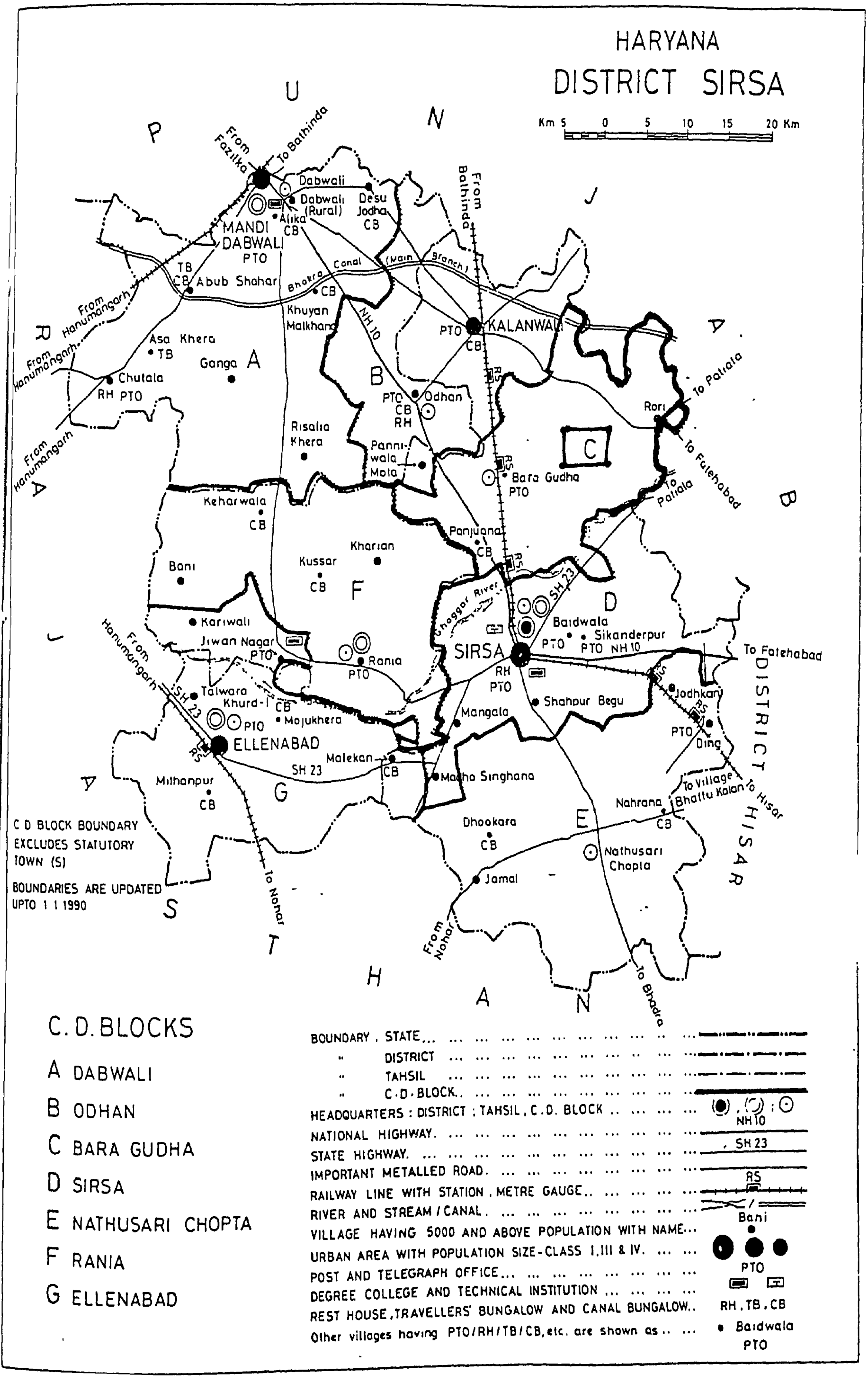
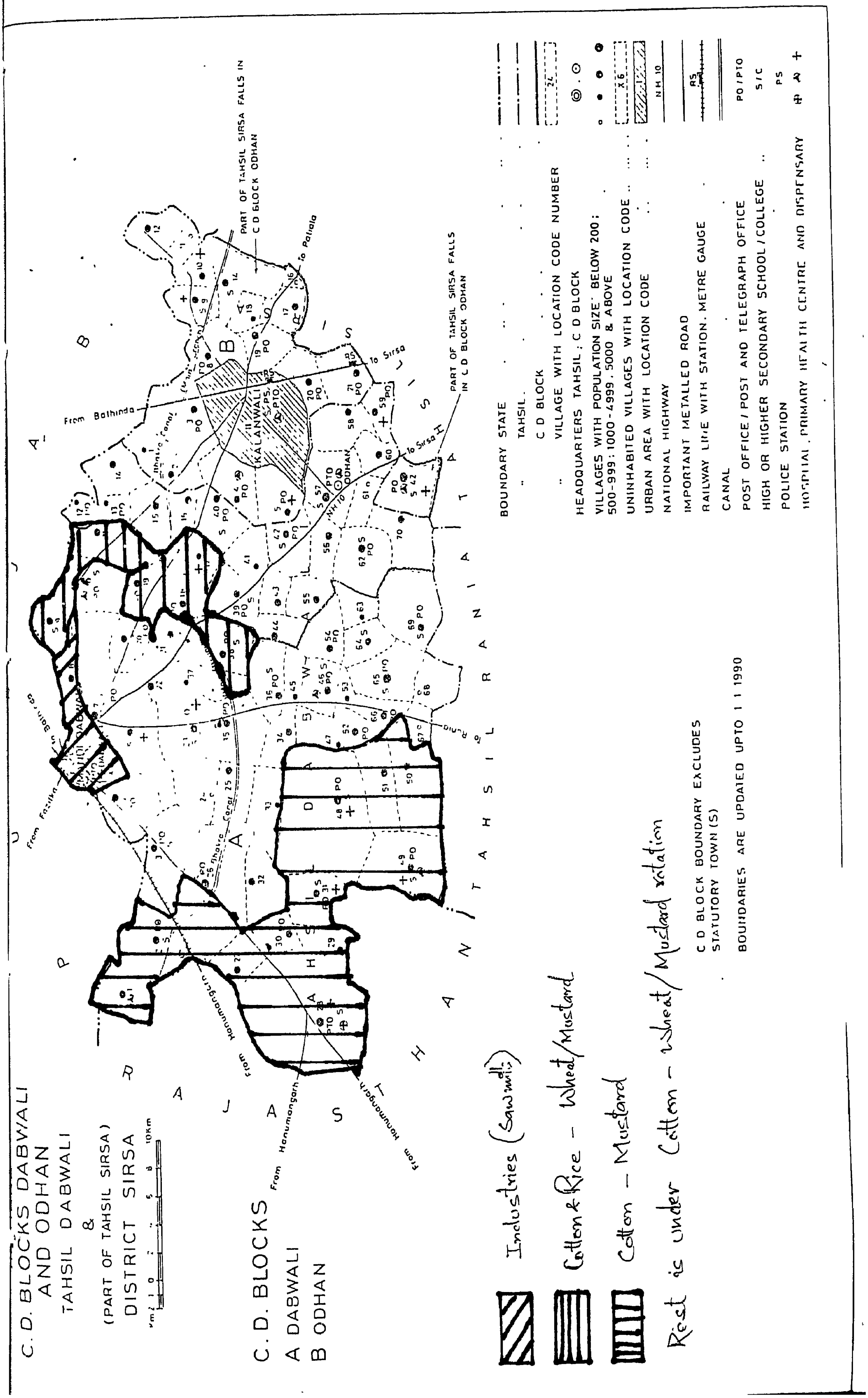
Appendix – I

Map of District Sirsa with Dabwali block marked



Map of Dabwali block with industries and copping pattern marked


C. D. BLOCKS DABWALI AND ODHAN
TAHSIL DABWALI
&
(PART OF TAHSIL SIRSA)
DISTRICT SIRSA
Km 1 0 2 4 6 8 10Km
C. D. BLOCKS
A DABWALI
B ODHAN
BOUNDARY STATE
" TAHSIL
" C D BLOCK
" VILLAGE WITH LOCATION CODE NUMBER
HEADQUARTERS TAHSIL; C D BLOCK
VILLAGES WITH POPULATION SIZE: BELOW 200; 500-999; 1000-4999; 5000 & ABOVE
UNINHABITED VILLAGES WITH LOCATION CODE
URBAN AREA WITH LOCATION CODE
NATIONAL HIGHWAY
IMPORTANT METALLED ROAD
RAILWAY LINE WITH STATION, METRE GAUGE
CANAL
POST OFFICE / POST AND TELEGRAPH OFFICE
HIGH OR HIGHER SECONDARY SCHOOL / COLLEGE
POLICE STATION
HOSPITAL, PRIMARY HEALTH CENTRE AND DISPENSARY
PO/PTO
S/C
PS
NH 10
RS
C D BLOCK BOUNDARY EXCLUDES STATUTORY TOWN (S)
BOUNDARIES ARE UPDATED UPTO 1 1 1990
PART OF TAHSIL SIRSA FALLS IN C D BLOCK ODHAN
PART OF TAHSIL SIRSA FALLS IN C D BLOCK ODHAN
From Bathinda
To Patiala
To Sirsa
To Sirsa
From Fazilka
To Bathinda
From Hanumangarh
From Hanumangarh
From Hanumangarh
Bhakra Canal
Ghaggar Canal
KALANWALI
ODHAN
DABWALI
NH 10
P U N J A B
R A J A S T H A N
T A H S I L S I R S A
T A H S I L
▨ Industries (Sawmills)
▥ Cotton & Rice – Wheat/Mustard
▥ Cotton – Mustard
Rest is under Cotton – Wheat/Mustard rotation

Annendix – III

Brief note on Gasifire technology

Biomass gasifier system

The gasifier system to be coupled to the diesel genset consists of (i) fuel processing unit (ii) main gasifier, (iii) gas cleaning/cooling train and (iv) waste utilization unit. These ar described briefly below.

The fuel processing system is designed so as to process most biomass residues. Th different routes for biomass processing are shown in Figure 1. It consists of a wood cutter, a chopper, a pulveriser and a ram and piston type briquetting (densifying) machine. Th wood cutter is primarily used for cutting long pieces of wood into smaller (~ 5 cm × 10 cm pieces, which are desirable as they ensure smooth fuel flow within the gasifier thus avoiding bridging. Agricultural residues like corn cobs, coconut shells, cashewnut shells etc. can be used directly without any preprocessing. Residues like mustard stalks, cotton stalks, lantan. etc. can be chopped and used directly, provided they have a reasonably good bulk densitie. (~ 250 kg/m^3). The chopper is a conventional chaf cutter extensively used in rural areas for fodder cutting. Biomass residues such as groundnut (peanut) shells will have to be pulverized and then densified. The pulveriser is a conventional hammer mill grinder available easily in the market. Items like saw dust can be directly briquetted. The briquetting machine is a commercially available ram and piston type, which has gained popularity and commercial acceptance in recent years. These units will use some of the power generated by the power plant. but as they are not used simultaneously, they do not draw heavy load. The electricity consumption for the various biomass processing units is in the range of 0.02-0.1 kWh/kg.

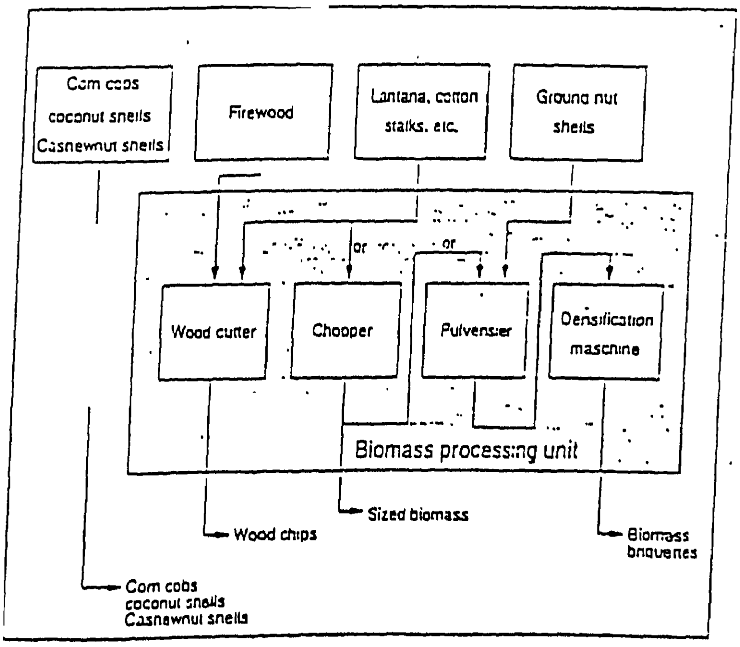


Figure 1. Routes for biomass processing

The main gasifier is a downdraft throatless design with a low specific gasification rate and provided with a continuous char removal system. It consists of a fuel hopper (storage bin), the reaction zone, a vibrating grate, all provided in a integral unit. In its travel through the gasifier, biomass drying and oxidation (combustion) undergoes followed by conversion to producer gas and char. The char is collected in a water pond below the grate and the gas is taken out through a bottom side port for further cleaning. Fuel is charged from the top through a gas-tight port, which is opened and closed, manually. The storage bin accommodates sufficient fuel for a 2 hour operation at full load. However, as the gasifier is under slight vacuum, fuel can be changed at frequent intervals without interrupting gas production or power generation. Two air nozzles are provided for combustion. The technical details of the gasifier are listed below.

Type : Downdraft, throatless
Specific gasification ratio : 0.1 Nm^3/cm^2 hr
Gas production : 2.3-2.5 Nm^3/kg
Gas calorific value : 1000-1200 $kcal/Nm^3$
Cold gas efficiency (energy in gas/energy in biomass) : 70-80%

The raw gas contains appreciable amounts of tar and solid particulate matter to the tune of 1500-2000 ppm. The impurity levels should be reduced to about 50 ppm before admitting the gas into any internal combustion engine. This is achieved by passing the gas through a series of units viz., a gravity settling chamber, a cyclone, a venturi scrubber, a packed bed scrubber, a sand bed filter and a paper filter, as shown in Figure 2. By the end of cooling/cleaning train, the producer gas is at ambient temperature and the total impurity content is down to 30-50 ppm. The water used for cleaning/cooling is recycled after screening for solid particles, and passing through a natural draft cooling tower.

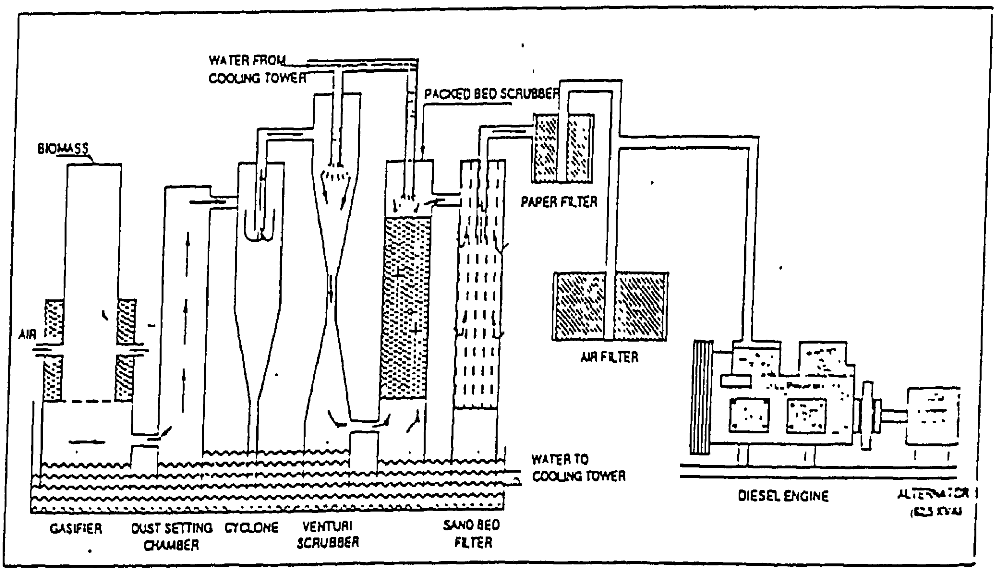


Figure 2. Schematic diagram of the gasifier based power generation set-up

The principle waste produced is biomass char and the tar and particulate matter collected while cleaning the gas. The gasifier is designed so as to produce char and not ash. The char and other solid matter collected in the water tanks is mixed and allowed to sun-dry for a day or two. After this it was fed to a low pressure screw extruder for making char briquettes. Analysis of these briquettes showed that they contain 50% carbon, 40% ash and minor quantities of hydrogen and nitrogen. The calorific value of the briquettes was in the range of 3500-4000 kcal/kg. The briquettes are thus suitable for sale as solid fuel to commercial enterprises like road side hotels.

The complete power plant

Gas produced from biomass as described above, is fed into a suitable diesel genset. The capacity and specifications of the genset are selected a-priori and the capacity of gasifier and other sub-systems are designed in accordance. For example, for a 62.5 kVA genset with 6 cylinders of swept volume 6.614 litre and 1500 RPM, the gasifier will have to be designed to consume about 50 kg biomass/hour. The producer gas, when burnt inside the diesel engine along with diesel oil, will replace upto 70% of diesel. The diesel replacement figures for a 50 kW gasifier power plant are shown in Figure.3 for different fuels. On a continuous basis, the power plant consumes about 108 ml diesel and 1.1 kg biomass to produce 1 kWh of electricity. Out of this, about 10% is used for parasitic consumption and the result is available either for feeding into the grid or for captive utilization.

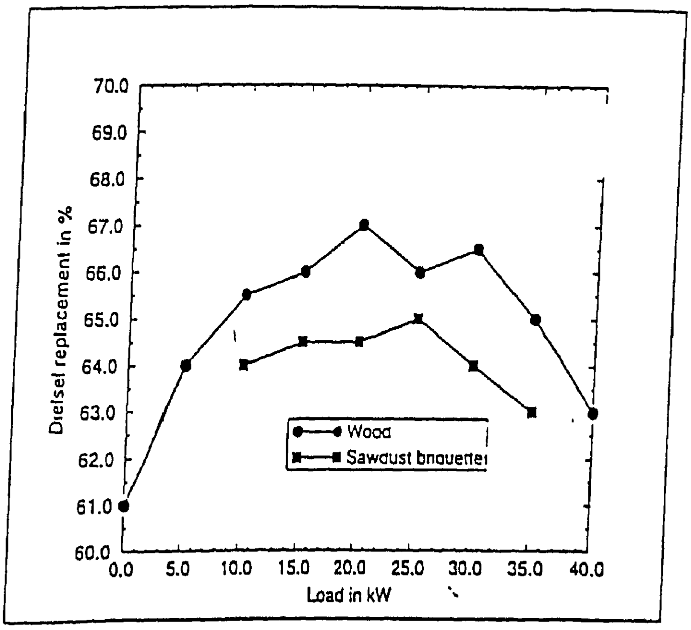


Figure 3. Diesel replacement achieved with dual fuel mode operation of diesel genset

Appendix - IV

List of groups developing Gasifires and Rice furnace

1. The Regional Centre for Extension Service
Modernisation of Rice Processing
Annamalai University, Annamalai Nagar
Tamil Nadu

2. The post Harvest Technology Scheme
College of Agricultural Engineering
Punjabrao Krishi Vidyapeeth
Akola, Maharashtra

3. Department of Processing and Agricultural Structures
College of Agricultural Engineering
Punjab Agriculture University
Ludhiana. Punjab

4. The Rice Processing Engineering Centre
Dept. of Agricultural Engineering
Indian Institute of Technology
Kharagpur, West Bengal

5. Department of Agricultural Engineering
College of Technology
G B Pant University of Agriculture & Technology
Pant Nagar, U. P.

6. Post Harvest Technology Scheme
Agricultural Engineering Institute
University of Agricultural Sciences
Raichur, Karnataka

7. M/s Krishi Sewa
Naroda Industrial Township
Naroda, Ahmedabad, Gujrat

8. M/s Wanson (India) Ltd.
Chinchwad
Pune, Maharashtra

9. M/s MG Industries
Batala, Punjab

10. IIT, Powai, Mumbai.

11. KSCST, IISc, Bangalore

12. IIT, Hauz khas, New Delhi.

13. School of Energy studies
Punjab Agriculture Unviersity
Ludhiana, Punjab.

14. Tata Energy Research institute
Habitat Place, Lodi Road
New Delhi - 110 003.

15. Thapar Corporate R&D Centre
Patiala, Punjab.

16. Ankur Scientific Energy Technologies Pvt. Ltd.
Near Old Sama Jakat Naka
Vadodra - 390 008, Gujrat.

17. M/s Associated Engineering Works
PB No. 17, Chivatam Road
Tanuku - 534 211

18. M/s Electrotech
E - 61, Industrial Phase - VIII
S.A.S. Nagar, Mohali, Punjab.

19. Janta Refractory & Steel Rolling Mills
C-159, Industrial Area
Site No. 1, B.S. Road, Ghaziabad, U.P.

20. M/s Cosmo Products
Ashoka Complex, Pachpedhi Naka
Dhamtari Road, Raipur - 492 001.

21. Grain Processing Industries (Indai) Pvt. Ltd.
29, Strand Road
Calcutta - 700 001. W. Bengal

22. Girnar Chemicals & Gas Industries Pvt. Ltd.
8, PUSHPAK
New Girdhar Park SOC.
Ambawadi, Ahemdabad - 380 006.

23. Netpro Renewable Energy (India) Ltd.
III Floor, GuptaTowers
50 / 1 Residency Road, Ist Cross
Bangalore - 560 025. Karnataka

Appendix – V List of major power consuming industries in the selected block

Note: There were no major power consuming industries in either Dabwali or Baragudda except a few saw mills and one briuette industry in Dabwali and a saw mill in Baragudda.

All the industries enlisted are located in and around Sirsa town.

Name of the Industry	Connected load (KVA)	Size of Generator set (KVA)
Gagneja Cotton & Ginning Mill	64	82.5
Ganga Cotton & Ginning Mill	140	125
Bhirumal Rice Mill	176	82.5
Hanuman Cotton & Ginning Mill	75	62.5
Patela Cotton & Ginning Mill	495	140 * 4
Garg Industries	499	140 *2
Sarea Rice mill	227	187
Hansraj Baburam Cotton & Ginning Mill	173	140 & 250
Jagdambey Paper Mill	2800 & 2400	1000 *2 & 750
Surja Ram Cotton & Ginning Mill	454	140
Ganesh Cotton & Ginning Mill	156	140
Maha Lakshmi Cotton & Ginning Mill	313	180
Sumeet Cotton & Ginning Mill	276	180
Satish Oil Mill	206	380

Appendix - VI Village-wise demography, livestock and landuse in the study area

Dabwali block

Village	Tot. Area (ha)	Population	Households	Forests (ha)	Irrigated land (h	Un-Irr. area (ha)	Culturable waste	Cattle/hh
AbubShahar	1516	1039	177		1290	806		10
Ahmadpur Derewala	2125	3735	594		2942	436		
Alika	2030	3215	502		2470	675		2
Asa Khera	1524	1896	319		1460	671		6
Banwala	1497	2509	411		1710	535		4
Bharu Khera	678							
Bijuwali	1816	5193	866		2286	453		3
Chakjalu	1293	1799	264		1640	391		
Chutala	933	2108	358		1618	58		3
Dabwali (Rural)	2464	5079	890		2728	883		6
Desu Jodha	1622	2037	298		1720	676		6
Dewan Khera	931	963	154		754	483		4
Faridpur	1215	1959	332		1512	336	13	
Fatehpur Jottanwali	1126	1540	247		1222	432		
Ganga	1194	2354	384		1660	288		3
Giddar Khera	685	1289	194		900	182		5
Gobindgarh	914.58	1118	174		1118	298		
Godeka	2214.41	3844	655		2944	603		6
Goria wala	1181	156	27		1696	292		3
Habuana	1188	2027	328		1840	174		10
Jandwala Bishnoian	4370.54	7506	1225		6960	231	171.54	3
Jhuti Khera	1015	2027	277		1718	110		7
Jogewala	7710	11959	1727		9566	2550		10
Kaluana	930	1593	241		930	400		5
Khuyan Malkhana	1075	2524	366		1682	162		6
Lakuana	2003	2727	357		2908	347		
Lambi	1689.94	2188	328		2976	2	99.94	3
Lohgarh	1422	944	146		1798	426		15
Mangiana	990	1066	123		1024	420		8
Masitan	2353	3051	516		3170	595		8
Matdadu	1424	2569	388		2054	297	1	5
Maujgarh	1134	913	157		1716	217		
Modi	2005	3708	606		2420	642		4
Mooanawali	666	824	118		824	212	2	3
NAi Dabwali	1072	2996	432		1314	317		
Nillanwali	1059	705	118		966	533		6
Pana	2438	7394	1232		4838	2316	8	6
Panniwala Moreka	3670	4058	599		2138	2344		5
Panniwala Ruldu	1984.95	2538	373		1027.9	1389.69		3
Phullo	1554	1486	234		1732	620		8
Rajpura	783	1407	208		582	429		5
Rampur	219	519	67		254	75		
Rampure Bishnoian	1246	1584	233		1080	620		
Ratta Khera	664	788	121		622	318	33	7
Risalia Khera	1068	1472	237		990	503	4	
Sakta Khera	2083	5241	754		1738	1009		2
SAnwant Khera	1118	1590	269		812	646		5
Shergarh	675.41	142	22		666	323		5
Sukheran wala	1001	53	7		1165.5	392.76		4
Teja Khera	2198	3207	508		1692	1227		

Appendix - VII Village-wise fuel mix in the study area

Village	Fuels consumed	(% family)				
Village	Fuels consumed					
	Crop residues	Dung cake	Fuelwood	K.oil	LPG	Biogas
AbubShahar	98	2				
Ahmadpur Derewala	98	2				
Alika	98	2				
Asa Khera	98	2				
Banwala	93	2	2	1		
Bharu Khera						
Bijuwali	93	2	2	1	1	1
Chakjalu	93	2	2	1		
Chutala	93	2	2	1		
Dabwali (Rural)	96	1	1	1	1	
Desu Jodha	98	2				
Dewan Khera	98	2				
Faridpur	98	2				
Fatehpur Jottanwali	98	2				
Ganga	98	2				
Giddar Khera	95	2	1	2		
Gobindgarh	97	1	1	1		
Godeka	97	1	1	1		
Goria wala	95	2	2	1		
Habuana	95	2	2	1		
Jandwala Bishnoian	98	2				
Jhuti Khera	97	1	1	1		
Jogewala	95	3	2			
Kaluana	95	2	3			
Khuyan Malkhana	95	3	1	1		
Lakuana	95	3	1	1		
Lambi	95	3	1	1		
Lohgarh	90	5	3	1		1
Mangiana	98	2				
Masitan	90	5	3	1		
Matdadu	90	5	3	1		
Maujgarh	90	5	3	1		
Modi	90	3	3	2	2	
Mooanawali	90	2	3	3	2	
NAi Dabwali	90	5	3	1		
Nillanwali	95	3	1	1		
Pana	97	2	1			
Panniwala Moreka	98	2				
Panniwala Ruldu	95	2	3			
Phullo	95	2	1	2		
Rajpura	90	3	2	2	2	1
Rampur	90	5	3	1		
Rampure Bishnoian	90	5	3	1		
Ratta Khera	95	2	2	1		
Risalia Khera	90	5	3	1		
Sakta Khera	90	5	3	1		
SAnwant Khera	92	3	2	1	1	1
Shergarh	95	2			3	
Sukheran wala	95	2	2	1		
Teja Khera	95	2	2	1		

Appendix - VIII Village-wise occupation pattern and land holding

Village	Occupations	(% family)				
Village	Occupations					
	Large Farmers	Medium Farmer	Small Farmer	Labour	Services	Shops
AbubShahar	25	50	25			
Ahmadpur Derewala	25	50	25			
Alika	25	50	25	25		
Asa Khera	5	70	25			
Banwala	5	70	25			
Bharu Khera						
Bijuwali	5	35	60	40		
Chakjalu	5	70	25			
Chutala	5	55	40			
Dabwali (Rural)	5	70	25	40		
Desu Jodha	10	50	40			
Dewan Khera	15	15	70			
Faridpur	5	70	25			
Fatehpur Jottanwali	5	70	25			
Ganga	10	60	30	30		
Giddar Khera	30	20	50			
Gobindgarh	15	40	45	20		
Godeka	0	70	30			
Goria wala	5	45	60	30	10	20
Habuana	5	55	40			
Jandwala Bishnoian	15	40	45	20		
Jhuti Khera	40	60				
Jogewala	5	45	50			
Kaluana	30	30	40	40		
Khuyan Malkhana	25	45	30	10		
Lakuana	15	40	45	20		
Lambi	5	40	55			
Lohgarh	15	30	55			
Mangiana	15	45	40			
Masitan	50	10	40	30		
Matdadu	20	40	40			
Maujgarh	15	40	45	20		
Modi	10	20	70	30		
Mooanawali	10	60	30	30		
NAi Dabwali	10	60	30	30		
Nillanwali	15	55	30	40		
Pana	50	10	40	40		
Panniwala Moreka	10	40	50	50		
Panniwala Ruldu	15	50	35	30		
Phullo	2	58	40			
Rajpura	10	55	35	40		
Rampur	10	60	30	30		
Rampure Bishnoian	10	60	30	30		
Ratta Khera	30	10	60	30		
Risalia Khera	10	60	30	30		
Sakta Khera	20	30	50	50		
SAnwant Khera	30	20	50	15	2	3
Shergarh	5	60	35			
Sukheran wala	25	15	60			
Teja Khera	10	60	30	30		

Appendix - IX Village-wise and crop-wise landuse in the study area (*Kharif*)

(Area in ha.)

DAbwali block

Village	Agri. land (h	Cotton Desi	Cotton Am.	Bajra	Pulses	Vegetable	GArden	Other
AbubShahar	1048.0	241.0	636.1	10.5	7.3	12.6	41.9	52.4
Ahmadpur Derewala	1689.0	388.5	1025.2	16.9	11.8	20.3	67.6	84.5
Alika	1572.5	361.7	954.5	15.7	11.0	18.9	62.9	78.6
Asa Khera	1065.5	245.1	646.8	10.7	7.5	12.8	42.6	53.3
Banwala	1122.5	258.2	681.4	11.2	7.9	13.5	44.9	56.1
Bharu Khera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bijuwali	1369.5	315.0	831.3	13.7	9.6	16.4	54.8	68.5
Chakjalu	1015.5	233.6	616.4	10.2	7.1	12.2	40.6	50.8
Chutala	838.0	192.7	508.7	8.4	5.9	10.1	33.5	41.9
Dabwali (Rural)	1805.5	415.3	1095.9	18.1	12.6	21.7	72.2	90.3
Desu Jodha	1198.0	275.5	727.2	12.0	8.4	14.4	47.9	59.9
Dewan Khera	618.5	142.3	375.4	6.2	4.3	7.4	24.7	30.9
Faridpur	924.0	212.5	560.9	9.2	6.5	11.1	37.0	46.2
Fatehpur Jottanwali	827.0	190.2	502.0	8.3	5.8	9.9	33.1	41.4
Ganga	974.0	224.0	591.2	9.7	6.8	11.7	39.0	48.7
Giddar Khera	541.0	124.4	328.4	5.4	3.8	6.5	21.6	27.1
Gobindgarh	708.0	162.8	429.8	7.1	5.0	8.5	28.3	35.4
Godeka	1773.5	407.9	1076.5	17.7	12.4	21.3	70.9	88.7
Goria wala	994.0	228.6	603.4	9.9	7.0	11.9	39.8	49.7
Habuana	1007.0	231.6	611.2	10.1	7.0	12.1	40.3	50.4
Jandwala Bishnoian	3595.5	827.0	2182.5	36.0	25.2	43.1	143.8	179.8
Jhuti Khera	914.0	210.2	554.8	9.1	6.4	11.0	36.6	45.7
Jogewala	6058.0	1393.3	3677.2	60.6	42.4	72.7	242.3	302.9
Kaluana	665.0	153.0	403.7	6.7	4.7	8.0	26.6	33.3
Khuyan Malkhana	922.0	212.1	559.7	9.2	6.5	11.1	36.9	46.1
Lakuana	1627.5	374.3	987.9	16.3	11.4	19.5	65.1	81.4
Lambi	1489.0	342.5	903.8	14.9	10.4	17.9	59.6	74.5
Lohgarh	1112.0	255.8	675.0	11.1	7.8	13.3	44.5	55.6
Mangiana	722.0	166.1	438.3	7.2	5.1	8.7	28.9	36.1
Masitan	1882.5	433.0	1142.7	18.8	13.2	22.6	75.3	94.1
Matdadu	1175.5	270.4	713.5	11.8	8.2	14.1	47.0	58.8
Maujgarh	966.5	222.3	586.7	9.7	6.8	11.6	38.7	48.3
Modi	1531.0	352.1	929.3	15.3	10.7	18.4	61.2	76.6
Mooanawali	518.0	119.1	314.4	5.2	3.6	6.2	20.7	25.9
NAi Dabwali	815.5	187.6	495.0	8.2	5.7	9.8	32.6	40.8
Nillanwali	749.5	172.4	454.9	7.5	5.2	9.0	30.0	37.5
Pana	3577.0	822.7	2171.2	35.8	25.0	42.9	143.1	178.9
Panniwala Moreka	2241.0	515.4	1360.3	22.4	15.7	26.9	89.6	112.1
Panniwala Ruldu	1208.8	278.0	733.7	12.1	8.5	14.5	48.4	60.4
Phullo	1176.0	270.5	713.8	11.8	8.2	14.1	47.0	58.8
Rajpura	505.5	116.3	306.8	5.1	3.5	6.1	20.2	25.3
Rampur	164.5	37.8	99.9	1.6	1.2	2.0	6.6	8.2
Rampure Bishnoian	850.0	195.5	516.0	8.5	6.0	10.2	34.0	42.5
Ratta Khera	470.0	108.1	285.3	4.7	3.3	5.6	18.8	23.5
Risalia Khera	746.5	171.7	453.1	7.5	5.2	9.0	29.9	37.3
Sakta Khera	1373.5	315.9	833.7	13.7	9.6	16.5	54.9	68.7
SAnwant Khera	729.0	167.7	442.5	7.3	5.1	8.7	29.2	36.5
Shergarh	494.5	113.7	300.2	4.9	3.5	5.9	19.8	24.7
Sukheran wala	779.1	179.2	472.9	7.8	5.5	9.3	31.2	39.0
Teja Khera	1459.5	335.7	885.9	14.6	10.2	17.5	58.4	73.0

Appendix - X Village-wise and crop-wise landuse in the study area (*Rabi*)

Dabwali (Area in ha.)

Village	Agri. land (ha)	Wheat	Gram	Pulses	Oil seed	Potato	Vegetable	Garden	Other
AbubShahar	1048.0	476.8	240.0	27.2	251.5	1.0	4.2	6.5	6.4
Ahmadpur Derewala	1689.0	768.5	386.8	43.9	405.4	1.7	6.8	10.5	10.3
Alika	1572.5	715.5	360.1	40.9	377.4	1.6	6.3	9.7	9.6
Asa Khera	1065.5	484.8	244.0	27.7	255.7	1.1	4.3	6.6	6.5
Banwala	1122.5	510.7	257.1	29.2	269.4	1.1	4.5	7.0	6.8
Bharu Khera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bijuwali	1369.5	623.1	313.6	35.6	328.7	1.4	5.5	8.5	8.4
Chakjalu	1015.5	462.1	232.5	26.4	243.7	1.0	4.1	6.3	6.2
Chutala	838.0	381.3	191.9	21.8	201.1	0.8	3.4	5.2	5.1
Dabwali (Rural)	1805.5	821.5	413.5	46.9	433.3	1.8	7.2	11.2	11.0
Desu Jodha	1198.0	545.1	274.3	31.1	287.5	1.2	4.8	7.4	7.3
Dewan Khera	618.5	281.4	141.6	16.1	148.4	0.6	2.5	3.8	3.8
Faridpur	924.0	420.4	211.6	24.0	221.8	0.9	3.7	5.7	5.6
Fatehpur Jottanwali	827.0	376.3	189.4	21.5	198.5	0.8	3.3	5.1	5.0
Ganga	974.0	443.2	223.0	25.3	233.8	1.0	3.9	6.0	5.9
Giddar Khera	541.0	246.2	123.9	14.1	129.8	0.5	2.2	3.4	3.3
Gobindgarh	708.0	322.1	162.1	18.4	169.9	0.7	2.8	4.4	4.3
Godeka	1773.5	806.9	406.1	46.1	425.6	1.8	7.1	11.0	10.8
Goria wala	994.0	452.3	227.6	25.8	238.6	1.0	4.0	6.2	6.1
Habuana	1007.0	458.2	230.6	26.2	241.7	1.0	4.0	6.2	6.1
Jandwala Bishnoian	3595.5	*******	823.4	93.5	862.9	3.6	14.4	22.3	21.9
Jhuti Khera	914.0	415.9	209.3	23.8	219.4	0.9	3.7	5.7	5.6
Jogewala	6058.0	*******	1387.3	157.5	1453.9	6.1	24.2	37.6	37.0
Kaluana	665.0	302.6	152.3	17.3	159.6	0.7	2.7	4.1	4.1
Khuyan Malkhana	922.0	419.5	211.1	24.0	221.3	0.9	3.7	5.7	5.6
Lakuana	1627.5	740.5	372.7	42.3	390.6	1.6	6.5	10.1	9.9
Lambi	1489.0	677.5	341.0	38.7	357.4	1.5	6.0	9.2	9.1
Lohgarh	1112.0	506.0	254.6	28.9	266.9	1.1	4.4	6.9	6.8
Mangiana	722.0	328.5	165.3	18.8	173.3	0.7	2.9	4.5	4.4
Masitan	1882.5	856.5	431.1	48.9	451.8	1.9	7.5	11.7	11.5
Matdadu	1175.5	534.9	269.2	30.6	282.1	1.2	4.7	7.3	7.2
Maujgarh	966.5	439.8	221.3	25.1	232.0	1.0	3.9	6.0	5.9
Modi	1531.0	696.6	350.6	39.8	367.4	1.5	6.1	9.5	9.3
Mooanawali	518.0	235.7	118.6	13.5	124.3	0.5	2.1	3.2	3.2
NAi Dabwali	815.5	371.1	186.7	21.2	195.7	0.8	3.3	5.1	5.0
Nillanwali	749.5	341.0	171.6	19.5	179.9	0.7	3.0	4.6	4.6
Pana	3577.0	*******	819.1	93.0	858.5	3.6	14.3	22.2	21.8
Panniwala Moreka	2241.0	*******	513.2	58.3	537.8	2.2	9.0	13.9	13.7
Panniwala Ruldu	1208.8	550.0	276.8	31.4	290.1	1.2	4.8	7.5	7.4
Phullo	1176.0	535.1	269.3	30.6	282.2	1.2	4.7	7.3	7.2
Rajpura	505.5	230.0	115.8	13.1	121.3	0.5	2.0	3.1	3.1
Rampur	164.5	74.8	37.7	4.3	39.5	0.2	0.7	1.0	1.0
Rampure Bishnoian	850.0	386.8	194.7	22.1	204.0	0.9	3.4	5.3	5.2
Ratta Khera	470.0	213.9	107.6	12.2	112.8	0.5	1.9	2.9	2.9
Risalia Khera	746.5	339.7	170.9	19.4	179.2	0.7	3.0	4.6	4.6
Sakta Khera	1373.5	624.9	314.5	35.7	329.6	1.4	5.5	8.5	8.4
SAnwant Khera	729.0	331.7	166.9	19.0	175.0	0.7	2.9	4.5	4.4
Shergarh	494.5	225.0	113.2	12.9	118.7	0.5	2.0	3.1	3.0
Sukheran wala	779.1	354.5	178.4	20.3	187.0	0.8	3.1	4.8	4.8
Teja Khera	1459.5	664.1	334.2	37.9	350.3	1.5	5.8	9.0	8.9